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Forest Pest
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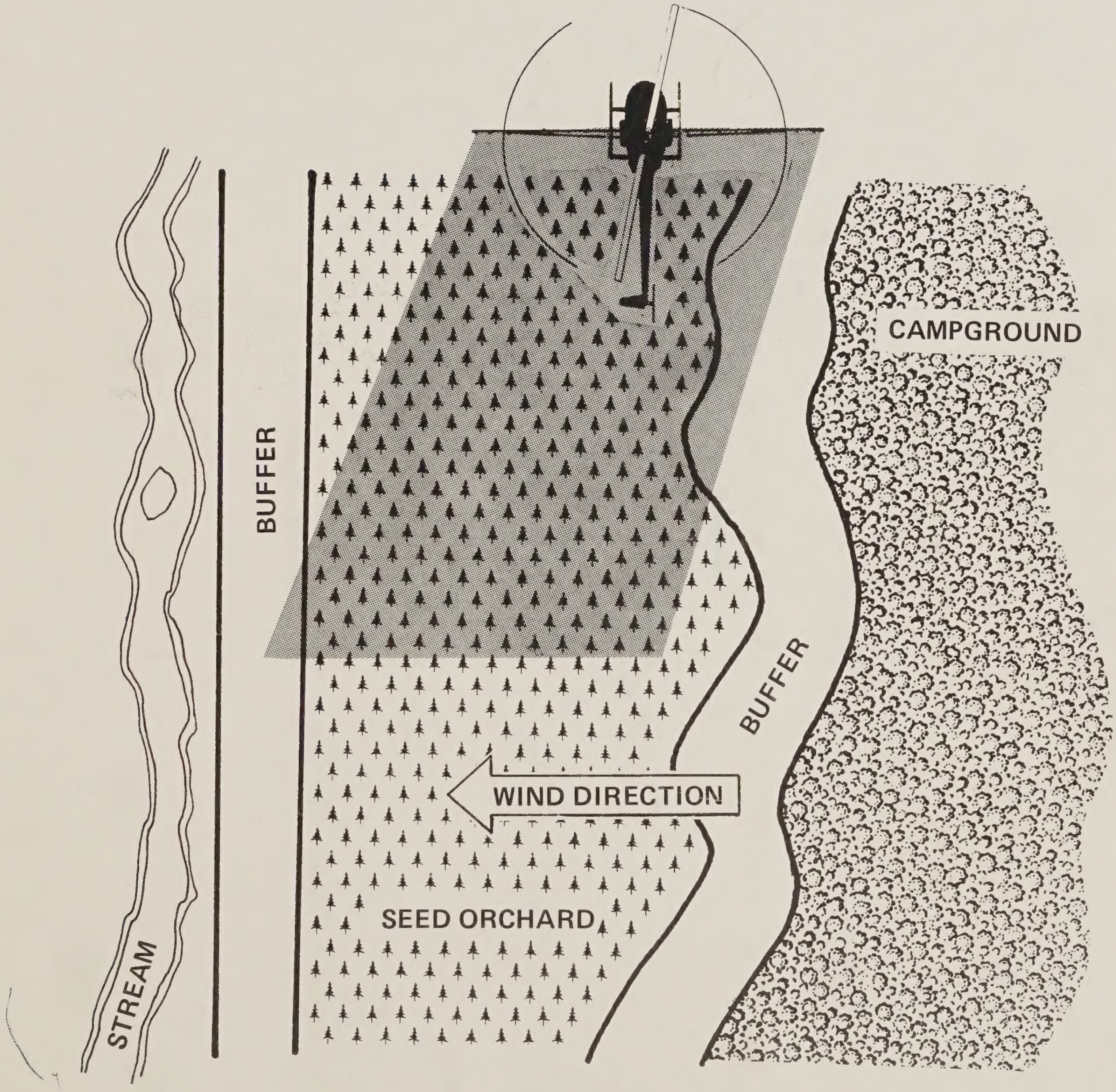
Davis, CA.

Modeling for Aerial Spray Buffer Zone



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MODELING FOR AERIAL SPRAY BUFFER ZONE

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PREFACE

Simulations performed by the H. E. Cramer Company, Inc., Salt Lake City, Utah, under contract to the USDA Forest Service, Forest Pest Management Staff, Davis, CA, demonstrate the utility of the Forest Service-Cramer-Barry-Grim (FSCBG) Forest Spray Model to predict drift of aerially applied herbicides downwind from a spray block containing seedlings or brush. Calculations of herbicide deposition described are based on a hypothetical spray scenario in which a tank mixture of water and 2,4-D was applied by a Hiller 12E helicopter to flat terrain. For the exercise the canopy-penetration feature of the FSCBG model was not used.

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Introduction

It is the U.S. Department of Agriculture, Forest Service (FS) policy to take all reasonable steps to reduce movement of pesticides off target, especially movement to water, roads, and inhabited areas. FS policy on establishing buffer zones for pesticide application differs amongst the nine FS regions. Policies and procedures are established by the regions. Regional guidelines and policies often are supplemented at the subordinate national forest level. The FS considers state and local governments' administrative rules and guidelines in establishing buffer zones. Each situation is thoroughly evaluated and all factors that may affect the environment are considered in the National Environmental Protection Act (NEPA) process.

Buffer zones are liberal for biological pesticide uses and considerably more limiting for chemical pesticide uses. Direct application of all pesticides is avoided over water, roads, dwellings, inhabited and other sensitive areas.

National forest system buffer zone widths generally are as follows: around water 8 to 152 meters, roads 30 meters, and inhabited areas 152 to 402 meters. The FS, however, insists upon strict adherence to the product label. If the label specifies a wider buffer than may be the practice, label buffers are used.

The width of a buffer zone depends upon how much spray is acceptable beyond the zone. Simply, the wider the zone the less spray depositing beyond the zone. Buffer zones on the upwind side of the treatment block can be narrower providing there is an organized and predictable wind flow. Most

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Paper presented by John W. Barry at Eastern Spruce Budworm Council "Buffer Zone Workshop" at Quebec City, 16-17 April 1986. The authors are John W. Barry, Pesticide Specialist, USDA Forest Service, Davis, CA; James E. Rafferty, Research Meteorologist, U.S. Army Dugway Proving Ground, UT; and Robert B. Ekblad, Mechanical Engineer, USDA Forest Service, Missoula, MT.

herbicide applications, however, are made in the early morning. At that time a transition exists from nighttime to daytime airflows when winds are characteristically variable. In most situations, therefore, it is prudent to set up an equal size buffer zone around the area to be protected.

Vertical temperature structure near the earth's surface can have a profound influence on spray cloud concentration downwind. Stable, stagnant air, characteristic of early morning, can entrap pesticide spray thus maintaining high air concentrations. As the air warms, the atmosphere mixes and the spray cloud is diluted. Vertical temperature structure should be considered when establishing buffer zones.

Pilot skill, canopy type, topography, tank mix, atomization, spray height, and aircraft type must also be taken into consideration when establishing buffer zones. It is beyond the scope of this paper to discuss these factors; however, I should like to point out that spray enters buffer zones through drift, and limitations of the pilot and equipment. Project officers have some control in dealing with these problems by contracting experienced and qualified applicators, use of proper equipment, and application of predictive models to various scenarios.

Method

This paper presents examples of spray deposit plots (Rafferty 1984) generated by the FSCBG (Forest Service Cramer-Barry-Grim) forest spray model (Dumbauld et al, 1980) of herbicide downwind of a spray block containing seedlings and brush. In the spray scenarios used as the basis for the model predictions of herbicide deposition, a Hiller 12E helicopter applied a tank mix of 95% water and 5% 2,4-D at a rate of 93.55 liters per hectare to the spray block. The spray block area was set equal to 48.6 hectares and the helicopter was assumed to fly along 40 swath lines, each 1000 meters in length, at heights of 3 and 15.2 meters above the top of the brush. A swath width of 12.2 meters was also assumed (Table 1).

In the FSCBG model calculations, the water in the spray mixture was allowed to evaporate while the 2,4-D was assumed to be nonvolatile. The initial drop-size distribution of the liquid spray mixture, used in the calculations, had a median drop size of 800 μm (Table 2). Other source parameter values used in the model calculations are given in Table 2. Model predictions were made for the three meteorological regimes (Table 3). The mean wind speeds and turbulence are based on climatological estimates presented by Dumbauld (1982). The meteorological inputs required by the FSCBG model for the three regimes and for the assumed spray release heights of 3 and 15.2 meters are shown in Table 4. The transport wind speeds are averages for the height interval extending from 2 meters above ground level to the spray release height. The values of turbulence have been adjusted for a source emission time of 2.5 seconds typical of aircraft spray systems and are also mean values between 2 meters and the spray release height.

Results

Plots of herbicide deposition isopleths (lines enclosing calculated deposition values equal to or greater than the isopleth value) for the two release heights and three meteorological regimes are presented in Figures 1

WINGSPAN (ROTOR LENGTH) (m)	10.8
AIRCRAFT WEIGHT (Kg)	1034
AIRCRAFT SPEED ($m\ s^{-1}$)	22.4
AIRCRAFT/SPRAY RELEASE HEIGHT (m)	3,15.2
SWATH WIDTH (m)	12.2
APPLICATION RATE (liters/hectare)	93.53
ACTIVE INGREDIENT FRACTION (%)	5

Table 1 - Source inputs to model.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Drop-Size Category	Mean Drop Diameter (μm)	Fraction of Total Mass in Category
1	3966	.001
2	2900	.009
3	2143	.02
4	1774	.03
5	1537	.04
6	1310	.10
7	1092	.10
8	951	.10
9	800	.20
10	661	.10
11	579	.10
12	501	.10
13	423	.04
14	355	.03
15	298	.02
16	209	.01

Note: The volume median diameter (VMD) of the distribution is 800 μm.

Table 2 - Drop-size distribution of spray atomization used as input to model.

Regime	Stability	Wind Speed at 2 m (meters per second)	Air Temperature (^{o}C)	Relative Humidity (%)	Turbulence Parameters (deg)	
					σ_A ($z=10m, \tau=600s$)	σ_E ($z=10m$)
1	Stable	0.9	16	80	10	3.5
2	Unstable	2.7	21	50	16	6
3	Unstable	4.5	32	30	13	5.3

Table 3 - Three meteorological regimes used for the model runs.

Regime	Release Height (m)	Transport Wind Speed ($m\ s^{-1}$)	Air Temperature (°C)	Relative Humidity (%)	Mean $\sigma_A(\tau=2.5s)$ (deg)	Mean σ_E (deg)
1	3.0	0.9	15.6	80	3.9	3.5
	15.2	1.2			3.5	3.5
2	3.0	2.7	21.1	50	6.3	4.5
	15.2	3.1			5.7	5.7
3	3.0	4.6	32.2	30	5.0	4.0
	15.2	5.1			5.0	5.0

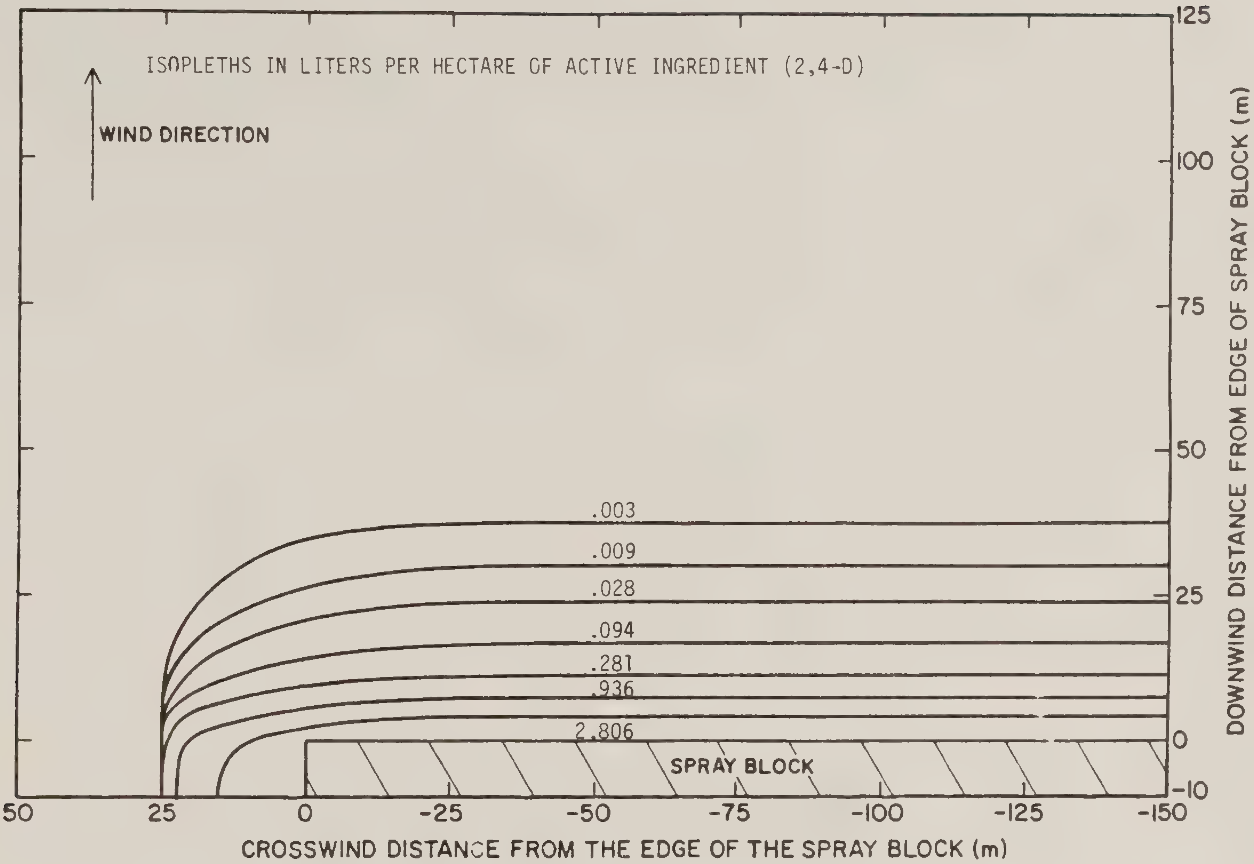
Table 4 - Meteorological inputs for each regime used in the model runs.

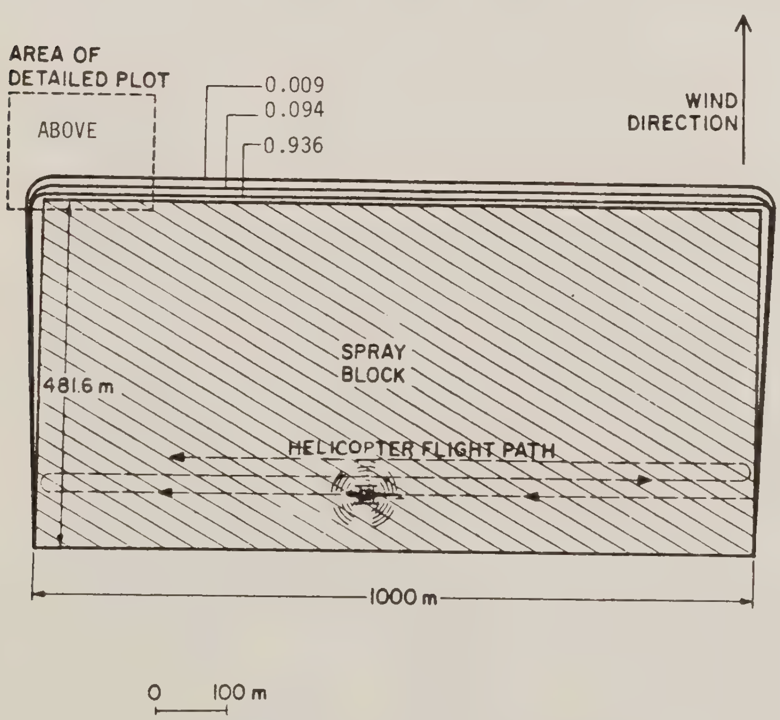
through 6. In each case, the deposition isopleths are labeled in units of liters per hectare of the deposited active ingredient 2,4-D. As shown in Figure 1, the drift of the herbicide beyond the downwind edge of the spray block is restricted to short distances under meteorological regime 1. This is due to low wind speeds, low turbulence values, and high humidity which reduce drop evaporation and thus results in large drop settling velocities. We have also constructed curves of 2,4-D deposition along the cloud drift centerline downwind from the spray block for the three meteorological regimes. These curves are shown in Figures 7 and 8 for release heights of 15.2 meters and 3 meters, respectively. As might be expected from qualitative reasoning, the model calculations show that the maximum distance of herbicide drift occurs for meteorological regime 3 under unstable and 10 mph winds (Figure 3) and a release height of 15.2 meters. Because of the low humidity assumed in this case, the water from the smallest drops of the initial drop-size distribution shown in Table 2 is completely evaporated before the drops reach the ground and thus drops of pure 2,4-D with small gravitational settling velocities are transported relatively large distances before they are deposited. In all the other example calcuations, the predicted deposition of herbicide does not extend beyond a distance of 100 meters from the downwind edge of the spray block. The model was used to calculate ground deposition. Conditions favorable for high spray cloud concentrations would differ from those which favor high ground deposition.

These results of the FSCBG model calculations indicate that, for herbicide spray applications, the herbicide drift downwind from the spray block is minimized by spraying at aircraft altitudes below 15.2 meters when the mean wind speeds are less than 4.47 meters per second.

Summary

Mathematical models are appropriate tools for calculating widths of buffer zones. The land manager, however, must decide how much drift is acceptable beyond the buffer zone and that in turn determines the width of the zone.





HELICOPTER	Hiller 12E
RELEASE HEIGHT	15.2 m
SWATH WIDTH	12.2 m
APPLICATION RATE	93.55 liters/hectare 2,4-D 4.68 liters/hectare
VMD	800 μm
WIND SPEED	0.89 mps
STABILITY	stable
TEMPERATURE	$16^{o}C$
RELATIVE HUMIDITY	80%

Figure 1. Prediction of drift for a release height of 15.2 m and a wind speed of 0.89 mps.

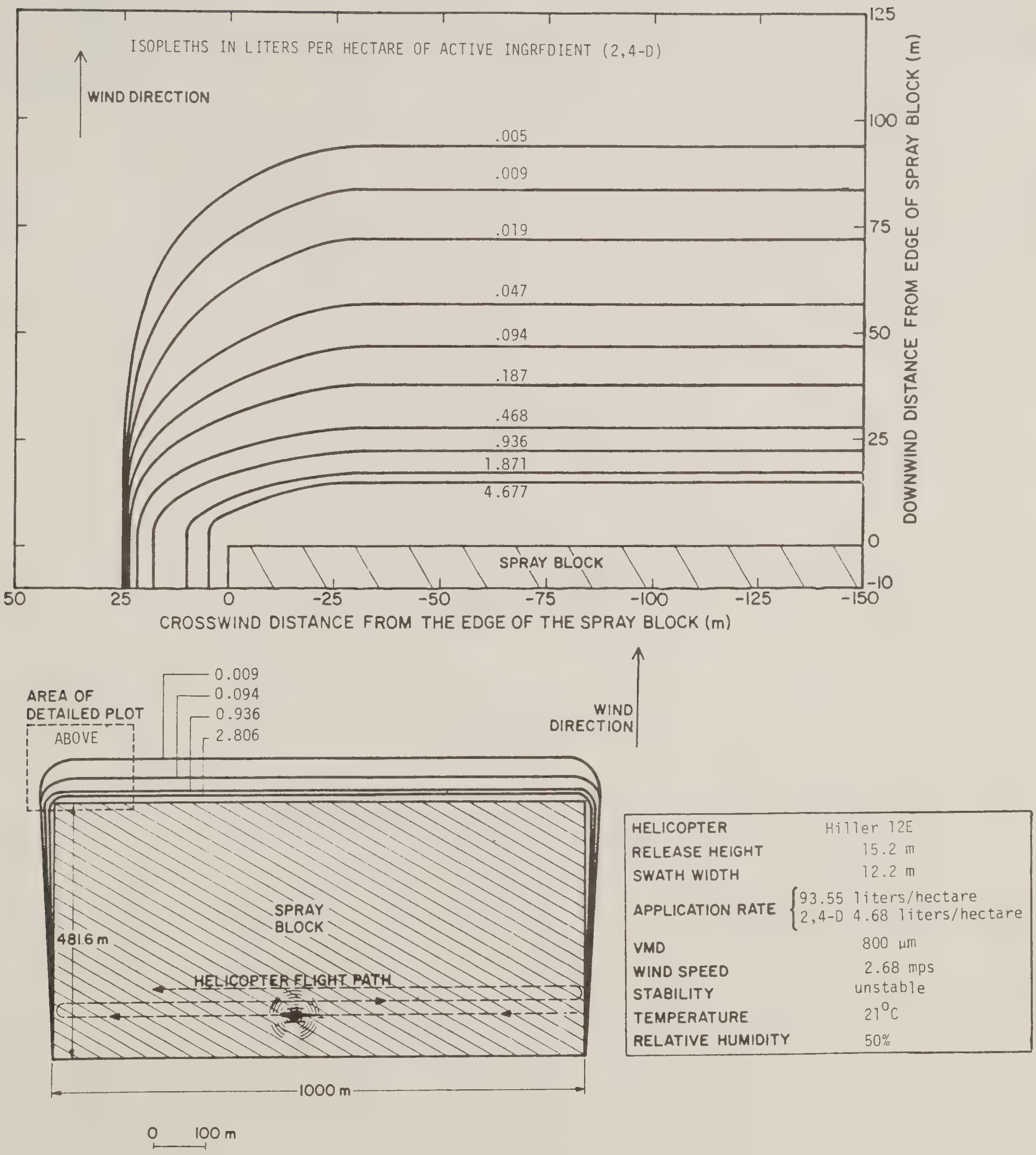
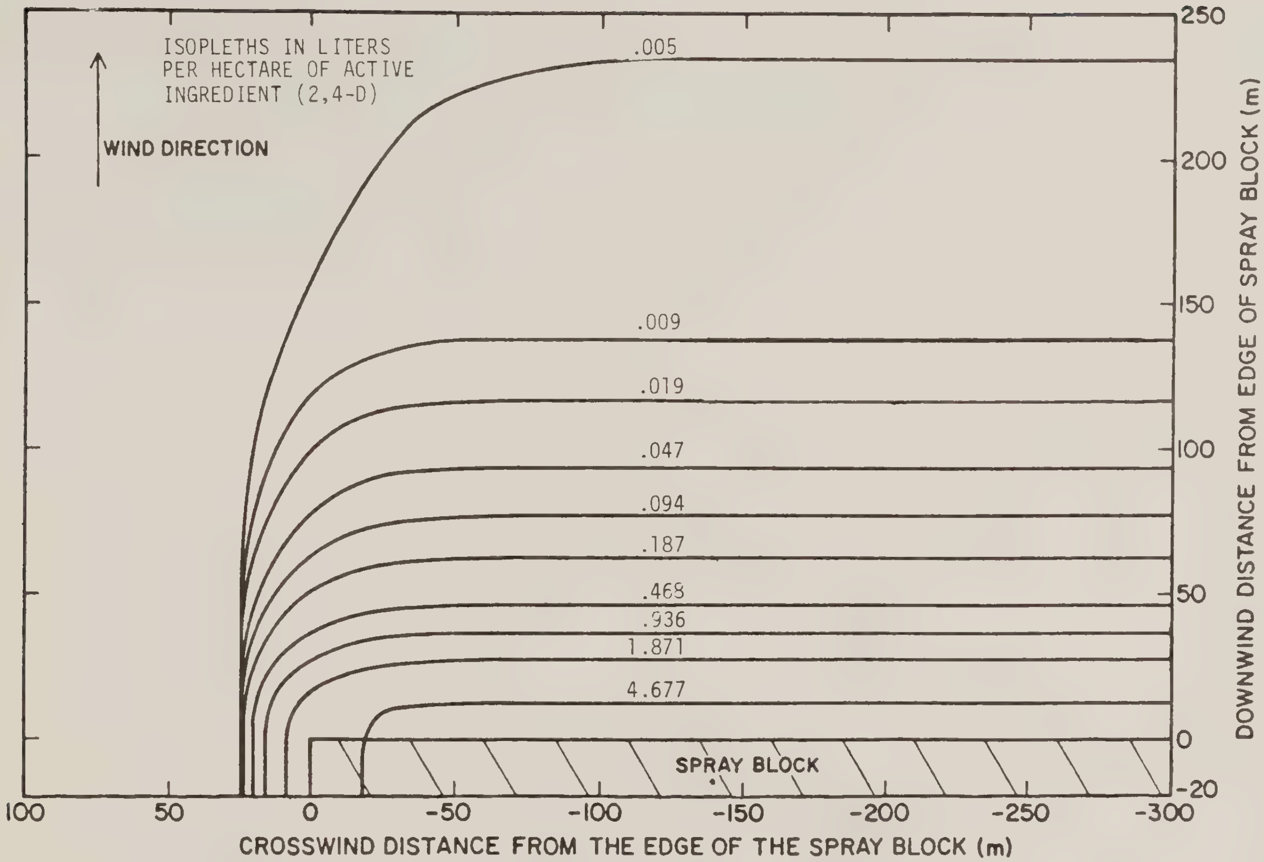
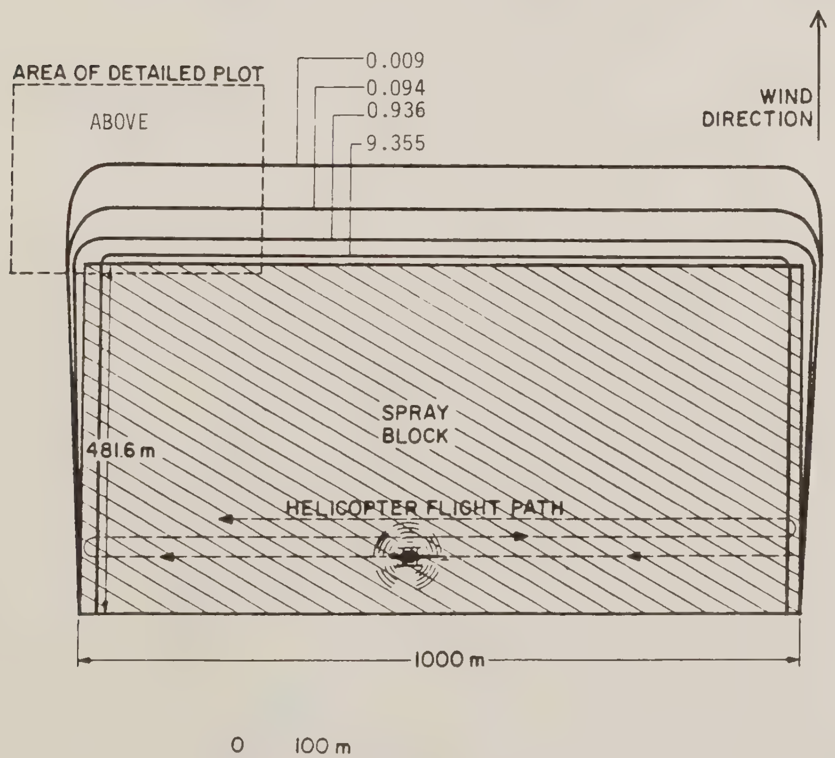


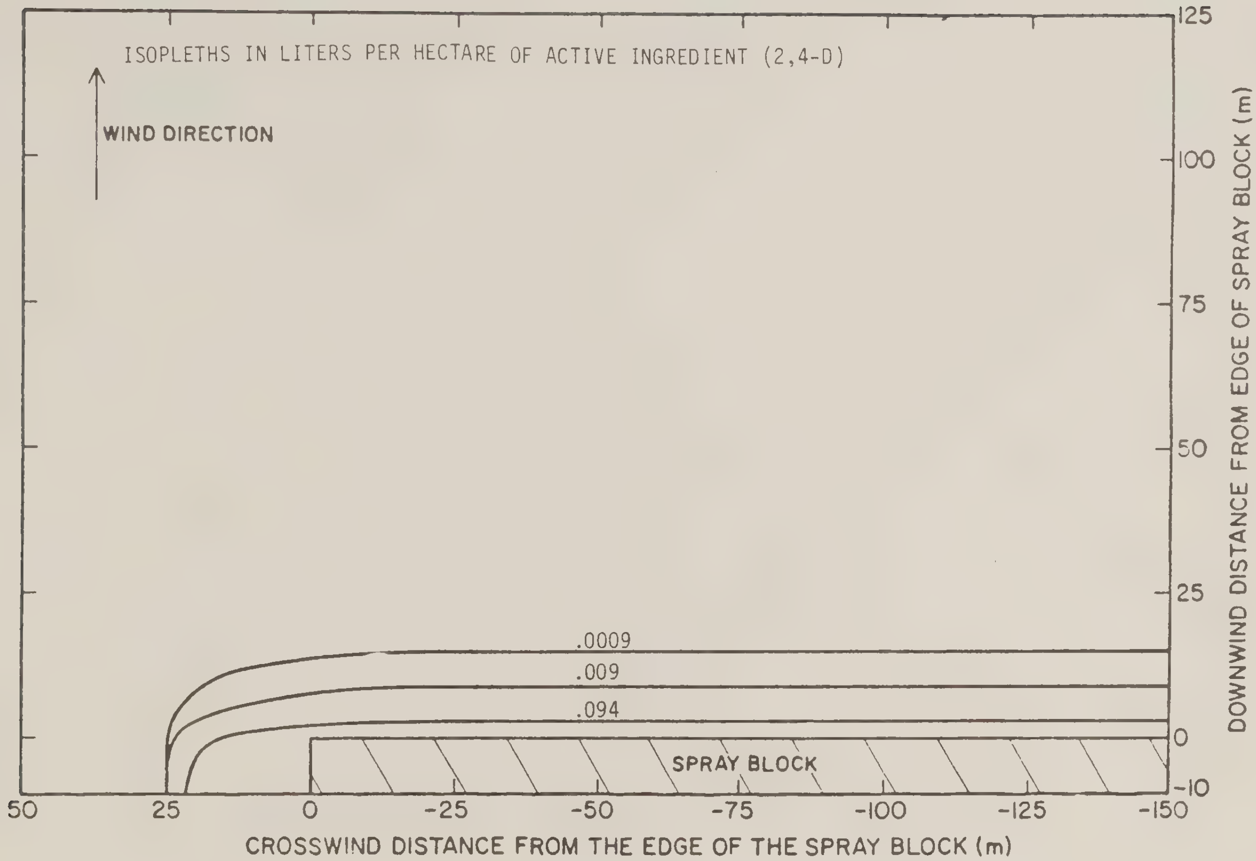
Figure 2. Prediction of drift for a release height of 15.2 m and a wind speed of 2.68 mps.

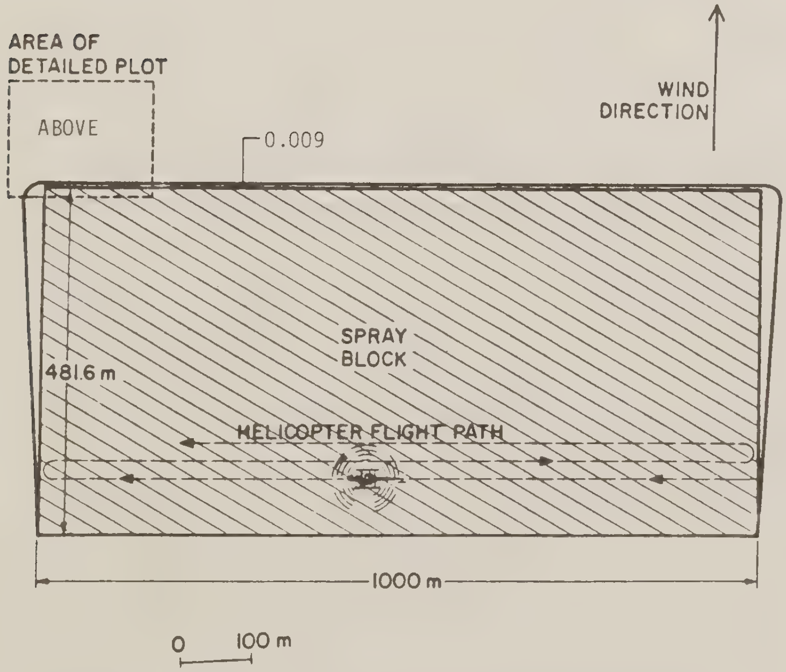




HELICOPTER	Hiller 12E
RELEASE HEIGHT	15.2 m
SWATH WIDTH	12.2 m
APPLICATION RATE	93.55 liters/hectare 2,4-D 4.68 liters/hectare
VMD	800 µm
WIND SPEED	4.47 mps
STABILITY	unstable
TEMPERATURE	32°C
RELATIVE HUMIDITY	30%

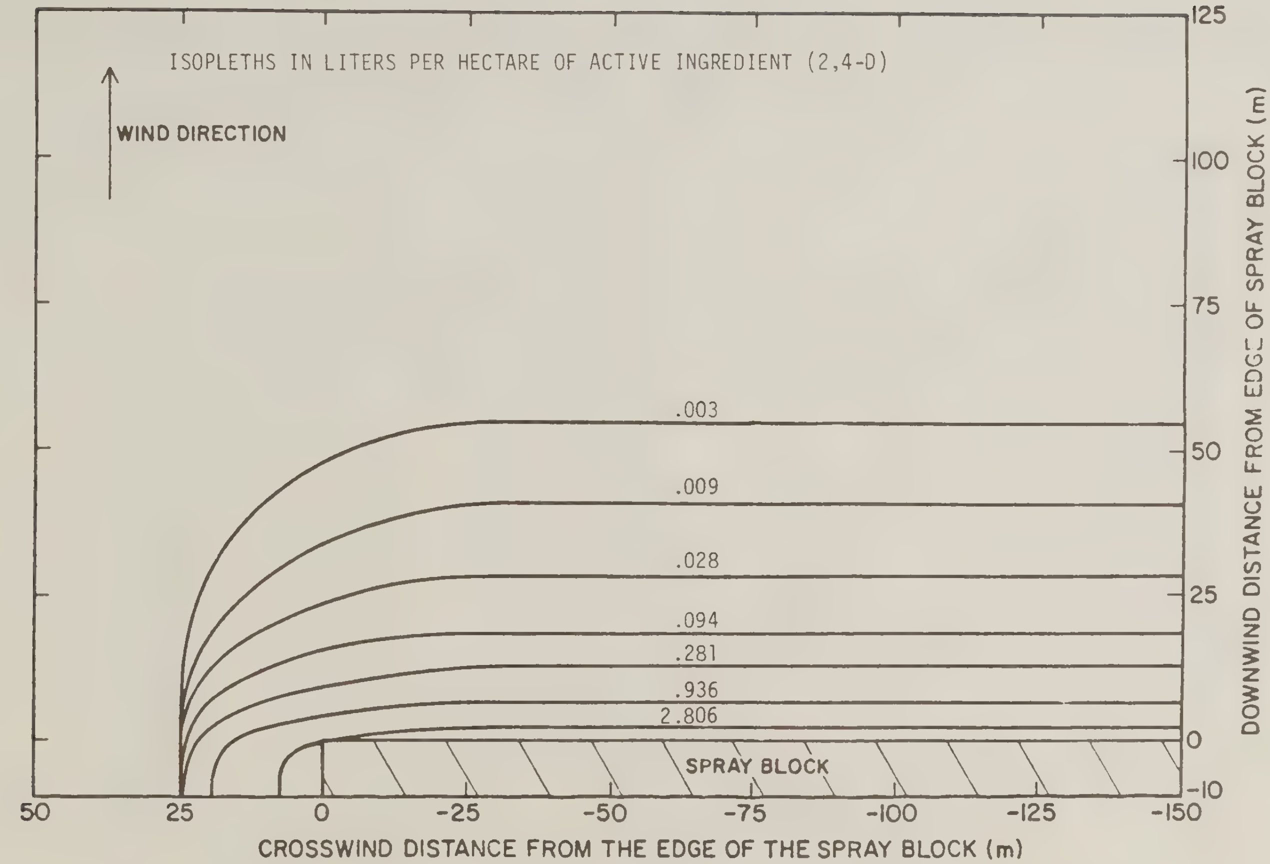
Figure 3 - Prediction of drift for a release height of 15.2 m and a wind speed of 4.47 mps.

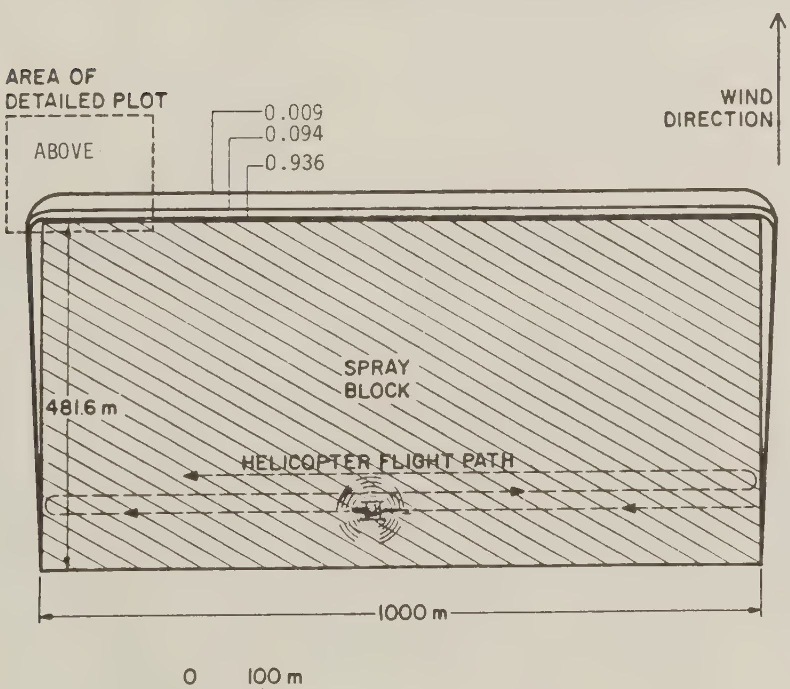




HELICOPTER	Hiller 12E
RELEASE HEIGHT	3.1 m
SWATH WIDTH	12.2 m
APPLICATION RATE	93.55 liters/hectare 2,4-D 4.68 liters/hectare
VMD	800 μm
WIND SPEED	0.89 mps
STABILITY	stable
TEMPERATURE	16°C
RELATIVE HUMIDITY	80%

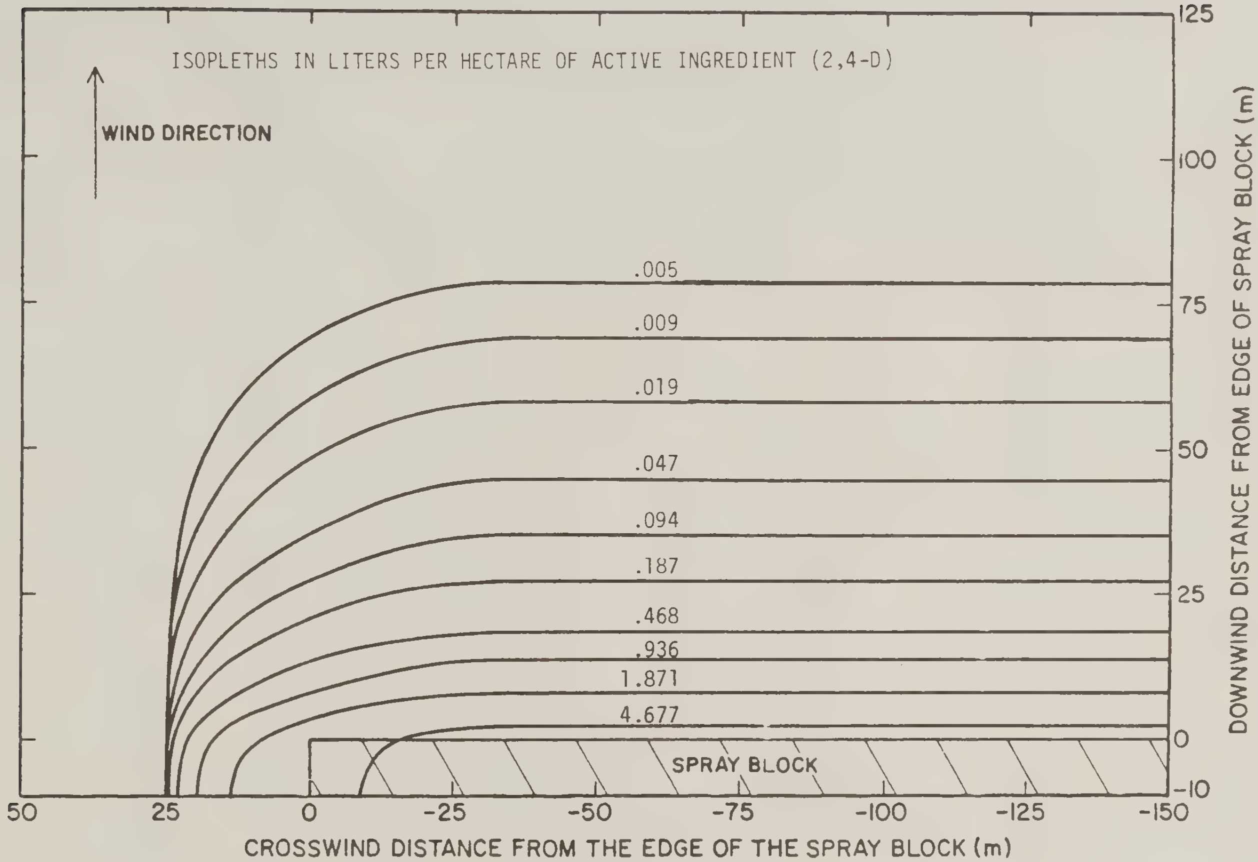
Figure 4. Prediction of drift for a release height of 3.1 m and a wind speed of 0.89 mps.

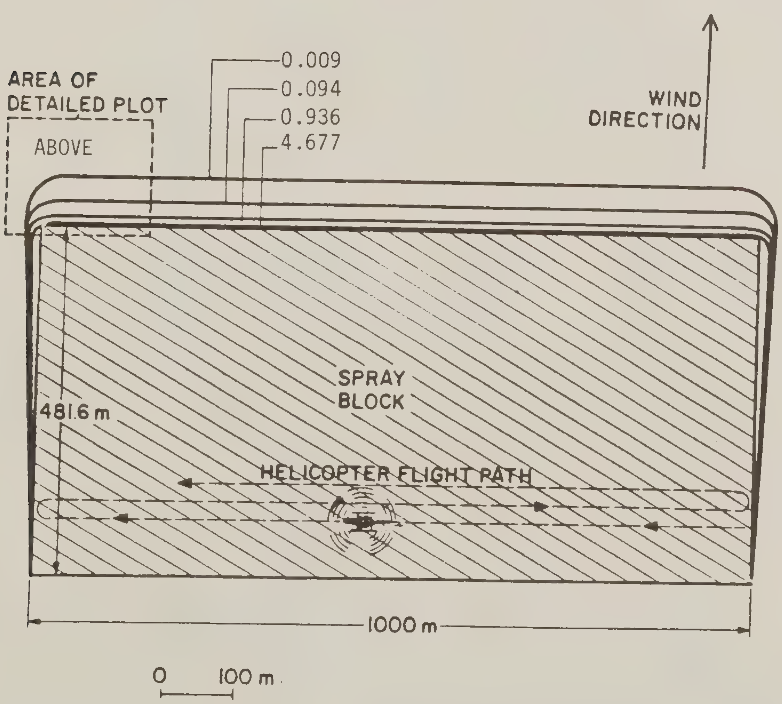




HELICOPTER	Hiller 12E
RELEASE HEIGHT	3.1 m
SWATH WIDTH	12.2 m
APPLICATION RATE	93.55 liters/hectare 2,4-D 4.68 liters/hectare
VMD	800 μm
WIND SPEED	2.68 mps
STABILITY	unstable
TEMPERATURE	21°C
RELATIVE HUMIDITY	50%

Figure 5. Prediction of drift for a release height of 3.1 m and a wind speed of 2.68 mps.





HELICOPTER	Hiller 12E
RELEASE HEIGHT	3.1 m
SWATH WIDTH	12.2 m
APPLICATION RATE	93.55 liters/hectare 2,4-D 4.68 liters/hectare
VMD	800 μm
WIND SPEED	4.47 mps
STABILITY	unstable
TEMPERATURE	32^{o}C
RELATIVE HUMIDITY	30%

Figure 6. Prediction of drift for a release height of 3.1 m and a wind speed of 4.47 mps.

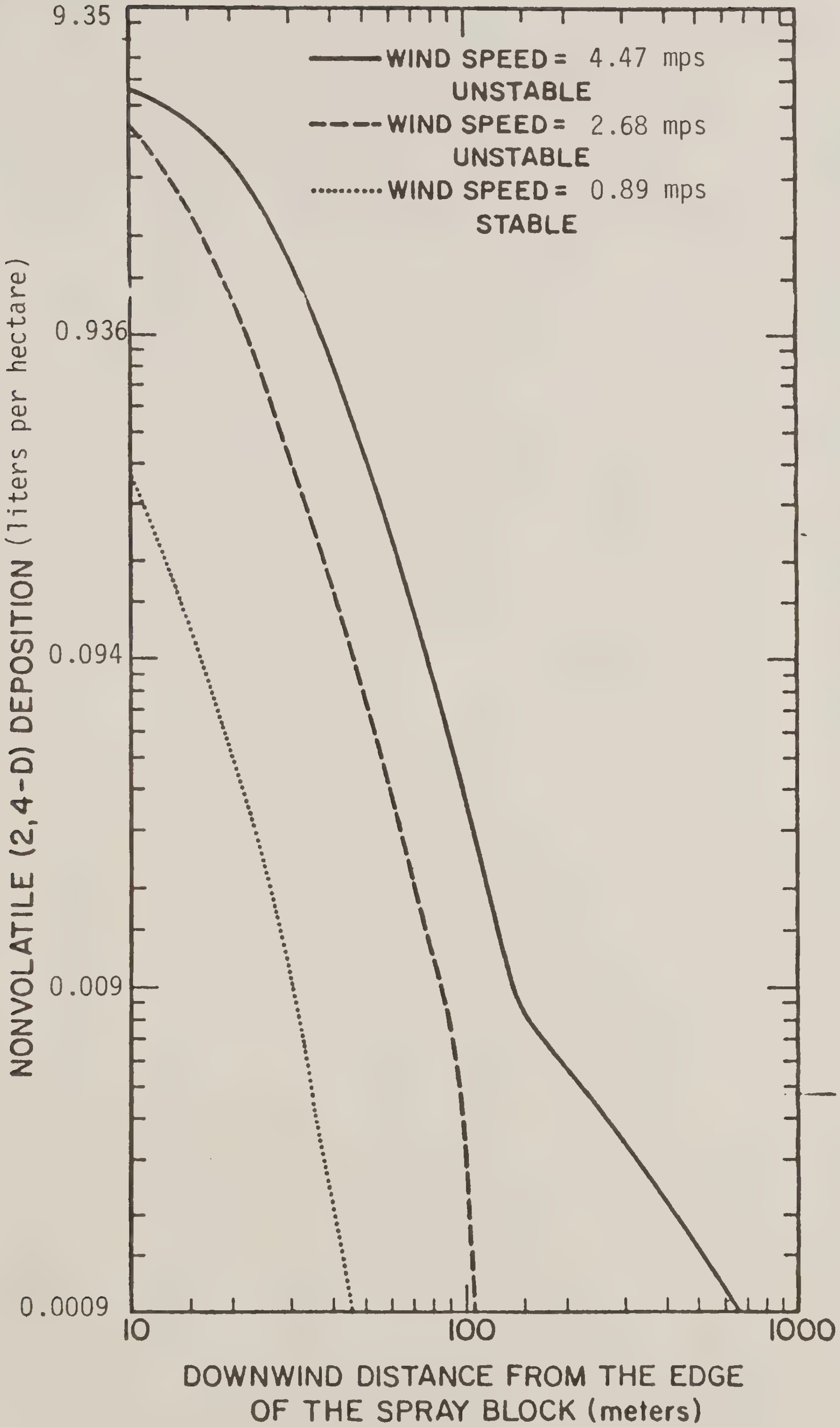


FIGURE 7. Centerline deposition for a spray release from a height of 15.2 m for three meteorological regimes.

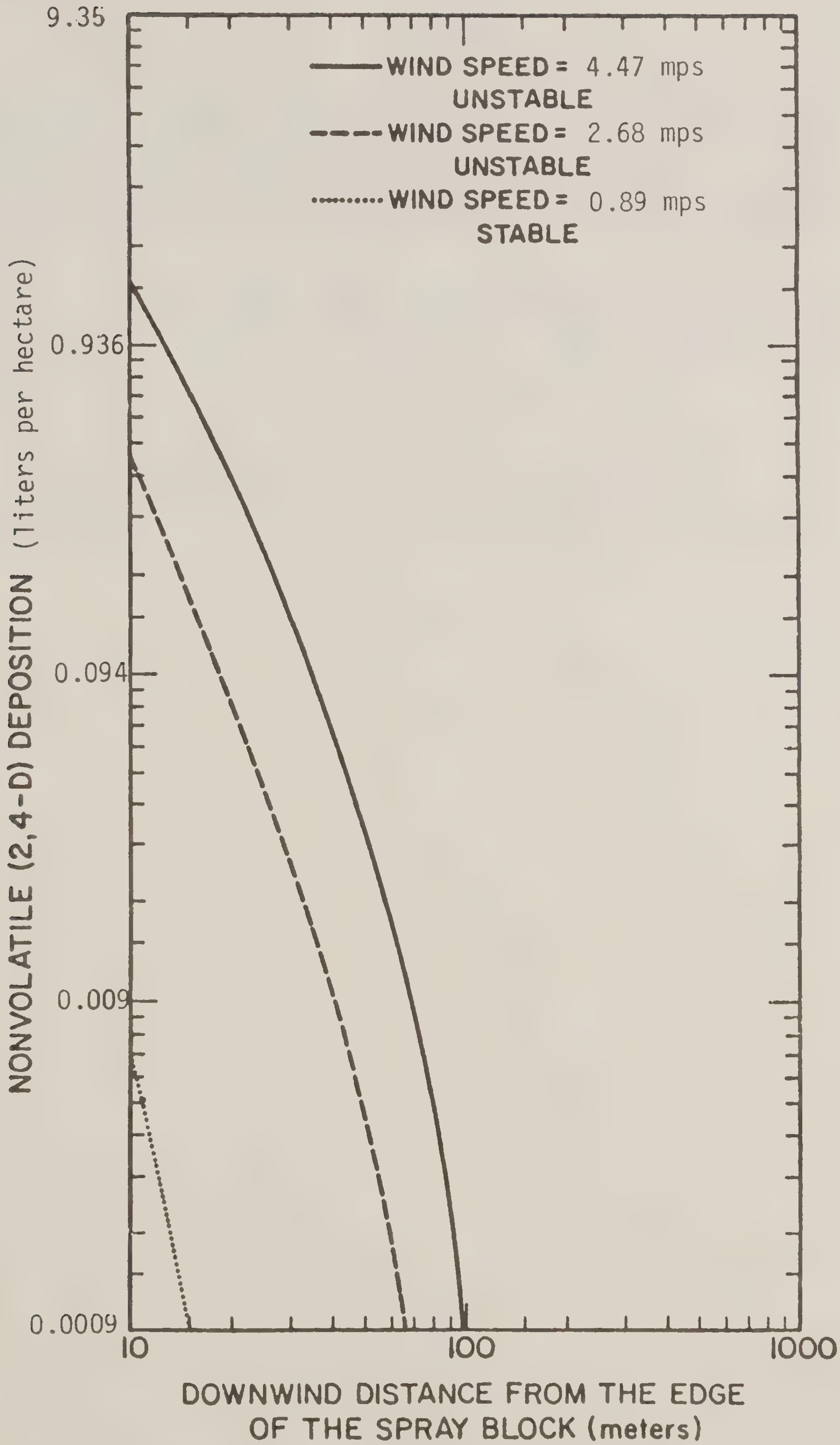


FIGURE 8. Centerline deposition for a spray release from a height of 3.1 m for three meteorological regimes.

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